CERN COURIER

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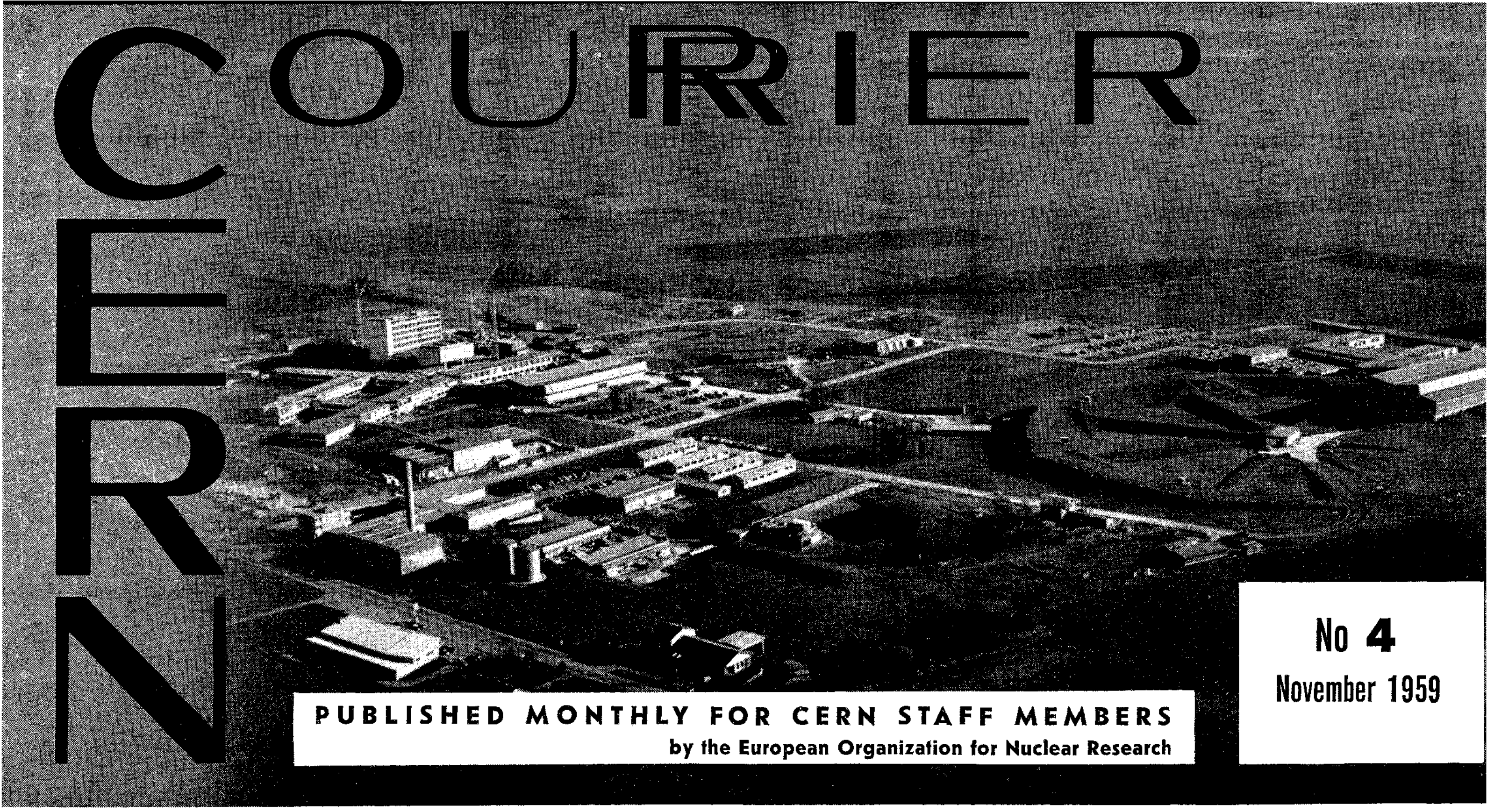

Last month at CERN

The most important event which has yet happened at CERN is the subject of the press release issued on 25 November and reproduced on this page. This news, which came just as the first proofs of this issue were coming off the press, was important enough to warrant rearranging the lay-out.

Testing of the proton synchrotron was interrupted during the first week of November. Modifications were carried out in the " linear accelerator " section and the electrostatic inflector was re-aligned. In the circular accelerator itself, the accelerating cavities were inspected. Part of the device for artificially perturbing the beam — the radio-frequency knock-out system — was also installed. Observation during tests had given reason to suppose some of the beam was lost in the region of the inflector. Two components obstructing the passage of the beam, a temporary observation screen support and a structural stiffening bar, were discovered at the junction of the beam inflection section with the circular vacuum tank.

In addition, beam oscillations were remedied by seeking the factors disturbing the uniformity of the magnetic field.

It could be said of the tests which were resumed later, that they were on the whole gradually improving the conditions under which the particles were injected. Towards 20 November particles were accelerated for about 200 millisecond and the

(see pages 6-7)

The European Organization for Nuclear Research (CERN) announces that for the first time on Tuesday November 24th 1959 at 7.40 p.m., reached its designed energy—producing a beam of protons of an energy of **24 thousand million electronvot.** This is the culmination of 6 year's work of design and construction at the CERN laboratories at Geneva. The machine, 200 metre across and the most powerful in the world, has thus justified its designers and the faith of the 12 nations of Western Europe who came together six years ago to form CERN. Western Europe has thus at its disposal a unique tool of research for the exploration of the inner structure of the atom.

This picture was taken under available light conditions in the proton synchrotron main control room, a few minutes after the machine reached its 24 GeV energy as mentioned above. From left to right are : Professor Ch. Schmelzer, P. Germain, W. Schnell, G. Rosset (in front of the oscilloscope) and J. Geibel. All belong to the radio frequency Group of the proton synchrotron and were among the 20-odd people who took part in the decisive tests of the accelerator.
(Photo J. Sharp)

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«CERN COURIER»

is published monthly for the staff of the European Organization for Nuclear Research. It is distributed free of charge to members of the Organization, to scientific correspondents and to anyone interested in problems connected with the construction and operation of particle accelerators or in the progress of nuclear physics in general.

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Who's Who in CERN

Markus E. FIERZ

Director of Theoretical Studies

Soon after young Markus' birth in Basel, on June 6th 1912, his father was appointed professor of organic chemistry at the Eidgenössische Technische Hochschule, the Federal Institute of Technology, Zurich.

And ever since it seems that all the life of Markus E. Fierz has revolved around this town, the largest of Switzerland. However far Markus Fierz's academic duties or likings took him, a universal attraction appeared to draw him back to the place where he first saw his father teaching.

When he entered Göttingen University in the winter of 1931, M. Fierz first turned to biology, hoping to achieve biophysical studies. But, prior to 1933, Göttingen was also a sort of Mecca for mathematics and theoretical physics and unquestionably this condition helped shape his future. With the Nazi purges starting in the spring of 1933, valuable minds began to leave Germany. Away from Göttingen came such men as Max Born and Herman Weyl ; back to Zurich came Markus Fierz.

Continuing his studies in physics, mathemathics and philosophy at the University of Zurich, he had the opportunity to attend Professor Carl G. Jung's seminars on psychology. Also in Zurich, under the influence of Professor G. Wentzel, he decided to become a theoretical physicist. February 1936 saw Markus Fierz finish his formal education with a doctorate thesis on "The artificial transformation of a proton into a neutron".

He returned then to Germany to attend seminars on theoretical physics at the University of Leipzig. This is the period which witnessed great academic debates between Heisenberg and Nordsieck and Bloch on the "infrared catastrophe", a problem already raised by Fierz in his doctorate thesis.

From Leipzig, Markus Fierz went to Copenhagen to attend one of the then famous conferences on theoretical physics at Bohr's Institute. There he met again with Wolfgang Pauli, professor of theoretical physics at the Zurich Federal Institute of Technology.

Before this, Pauli and Fierz's relations had been the usual ones between professor and student. Now Pauli asked him to become his assistant. Somewhat apprehensive, Markus Fierz however decided to accept and for three years starting in the winter of 1936, he was scientific collaborator of the discoverer of the exclusion principle.

Together with him he published a paper on the "H Theorem" relating to the quanta theory. During this period, M. Fierz also published scientific papers on "A relativistic theory for particles with arbitrary spin" and another on "The form of beta spectrum for a general interaction". This paper made Markus Fierz best known among experimental physicists because in it were deduced the so-called "Fierz terms", parameters which, their author insists with some humour, "do not exist".

Married in the spring of 1940, M. Fierz left Pauli in the summer of the same year. He was, however, to keep in close touch with the then Nobel prizewinner to be. In point of fact, they where to exchange a large scientific and philosophic correspondence, until Pauli's death in December 1958.

Markus Fierz became privat-docent and assistant at the Physics Institute, University of Basel, where he was to teach for about 20 years. Extraordinary professor in 1943, ordinary professor in 1945, he was then to participate to the extensive interchanche of professors going on in the world after World War II. He was guest at the Institute for Advanced Studies, Princeton, in 1950-51 and in 1955, a visiting professor at College Park, Maryland University.

Among the papers published by Professor Fierz during his teaching years, are articles on "Multipolar radiation", "Meson theory", "Statistical mechanics" and "General relativity". Also remarkable is a "Historical essay on Newton's conception of the space-time relation" which betrays one of Professor Fierz's hobbies : history.

On April 1st, 1959, Professor M. Fierz joined CERN as head of the Theoretical Studies Division.

Next year on April 1st, Zurich's lasting influence on Markus Fierz will be fully established. Professor Fierz will then return to his favourite city for a most exalting purpose. He and Professor Res Jost have been appointed successors to Pauli, to teach theoretical physics at the Eidgenössische Technische Hochschule, Zurich.

The "CERN COURIER" Referendum

The CERN staff has given its opinion about the contents and presentation of its " COURIER ".

Out of 1000 questionnaires sent to all recipients of our periodical, inside the Organization, 436 had been returned by 11 November, the closing date. This is an exceptionally good response when it is remembered that the editor of a paper who puts questions to his readers considers himself lucky if he gets an answer from more than 5 % of them.

Three hundred and fifty staff members are satisfied with the presentation of the periodical, 77 regard it as average and 9 do not express an opinion. As regards form, 360 readers are in favour of a journalistic style, although some of them figure among the 87 who would like a more restrained style.

Some most constructive remarks were made about the contents. Seven readers suggested that CERN physicists and experts should publish news articles about their scientific activities which could be easily understood by non-scientific readers. It would be interesting from several points of view if there could be some response to these requests... which, moreover, back up that made every month in the "CERN COURIER".

Requests are also made for more biographical articles, more news about present and future work at CERN and more information about other accelerators — and even about reactors. It is also suggested to announce forthcoming seminaries and lectures. As is the case for the "Readers' page", this suggestion would be enthusiastically adopted if enough material was received.

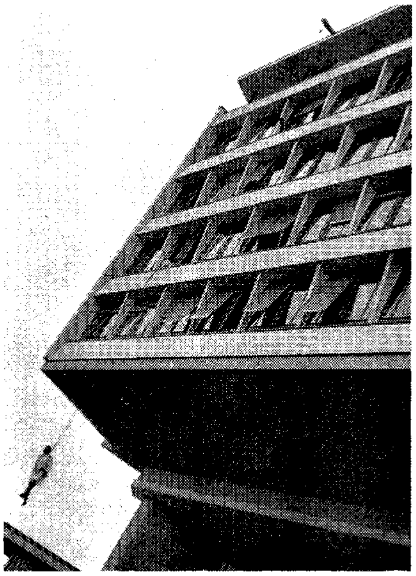
As for the publication of the names of staff members, the general opinion is clear : 346 "for", 58 "against" and 32 "don't know".

The distribution of the "CERN COURIER" outside the Organization gives rise to various comments. It can be held, however, that this helps to make CERN better known, even if the contents of the periodical are mainly intended for the staff.

(see page 6)

SAFETY AT CERN

Regular exercise take place at CERN to test the efficiency of the fire brigade and to train volunteers. This photo shows B. Agostinetti being « rescued » from the top floor of the Administration Building, during a demonstration of equipment. Of course, there are more normal ways of leaving this building... (CERN Photo)



Staff safety is rightly considered to be of major importance in any undertaking.

At CERN, a Safety Committee was set up in December 1956. This consists of representatives of each division and of the Safety engineer. Their task is to prevent accidents from occuring to the staff in the course of duty.

For this purpose the Safety Committee

- — publishes lists of precautions to be taken and safety codes to the staff ;
- — studies the plans and drawings of new buildings and installations from the point of view of safety and fire risks ;
- — analyses the accidents occuring at CERN, in order to avoid repetition.

It will be noticed that special measures are taken by the Health Physics Section of the Scientific and Technical Services Division, against radioactivity hazards which may result from the operation of the accelerators.

Some of the activities of the Safety Committee in 1958 are listed below :

- — suggesting regular medical examinations with a view to diagnosing possible occupational diseases apart from those due to radiation ;
- — regular inspection of portable electric tools ;
- — precautions to be taken when using liquid hydrogen bubble chambers ;
- — studying different methods of decontaminating equipment and premises including the selection of protective clothing ;

In collaboration with the PS Radio Frequency Group the Committee considered what safety equipment should be placed on the 16 PS accelerating cavities as a radio frequency voltage of over 8000 volt is applied to this apparatus.

Apart from studies and technical work such as outlined above, the Safety Committee deals with more down-to-earth issues. Thus, in 1958, a system of traffic control was initiated on the CERN Site.

But the best safety measures cannot, alas, ensure complete personal safety. The unpredictable human element also comes into the picture. The precautions imposed are often treated as so many difficulties to be overcome and only too frequently this attitude leads to regrettable accidents.

There were 61 accidents at CERN in 1958. Out of this total 23 were due to inattention, 17 to carelessness and only 8 to working conditions.

The circumstances in which these accidents happened were as follows : handling equipment (10), knocks and falls (9), splashing with harmful substances (8), use of tools and machines (7). A single case of over-exposure to radiation—not of a serious nature, however —was recorded in 1958 by the Health Physics Section.

On the whole, the accidents were not very serious : out of the 61 accidents, 3 resulted in fractures, 6 in burns, 2 in electric shocks, hernia or infections.

Divisions	"tf" frequency (*)		"tg" frequency (*)	
	1957	1958	1957	1958
Site and Buildings	7.8	5.02	0.96	0.34
Proton Synchrotron	4.7	3.88	0.27	0.167
Synchro-cyclotron	1.9	5.1	0.14	0.15
Scientific and Tech. Serv.	2.8	1.75	0.04	0
Directorate General Theoretical Studies Administration	0	0.89	0	0.06
Total CERN	3.8	3.64	0.35	0.175

(*) « tf » represents the number of accidents per 100 000 working hours. « tg » shows the number of days lost through accidents per 1000 working hours. Average tf and tg rates below 8 and 1 respectively, may be regarded as acceptable.

- — determining the blood groups of staff members in case blood transfusions should prove necessary.

In the course of 1958, the concrete slabs covering the conduits in the synchrotron halls were inspected and breaking tests were undertaken to ascertain their mechanical resistance. Several auxiliary ventilation systems have been installed, in particular one for removing trichloroethylene vapour from the "linear accelerator" wing of the synchrotron, and one in the paint-spraying cabin in the Main Workshop.

Liquefying hydrogen is a dangerous operation. Not only must it be carried out at a temperature of minus 246° C. but also any spark or source of heat which might ignite the product must be avoided. These considerations prompted the Committee to issue safety rules for the manufacture, transport and use of liquid hydrogen.

The table above shows the number of accidents per 100 000 working hours in 1957 and 1958 and the number of days lost through accidents per 1000 working hours over the same period.

These figures do not include accidents involving contractors' staff working on the site. Contrary to 1957, when there were two fatal accidents among the outside teams, there was only one serious accident, a case af electric shock at 6000 volt which luckily did not prove fatal.

During the year under review three cases of poisoning by toxic substances were detected, thanks to the regular examinations which the staff undergoes. During the same period, 2 494 cases received first-aid at the three first-aid stations or from 25 CERN first-aid boxes; 374 were members of outside teams. Forty-two cases had to be admitted to hospital or receive treatment there.

The Safety Committee also deals with fire fighting questions. CERN employs 14 professional firemen and 43 staff members have been specially trained to assist them in case of need. The fire men have appropriate equipment, which enabled them in 1958 to deal with 23 small fires, 107 cases of flooding, 18 gas leaks, minor explosions, etc.

In the conclusions of the report on site Safety presented by the Chairman of the Committee, Mr. F. A. R. Webb, mention is made of the improvement in cooperation from the staff on safety matters. It is also pointed out that "the difficulties of reconciling various national and individualistic ideas on safety must not be forgotten".

In this respect, as in others, CERN is a new field to try out methods whose progress is most interesting to follow.

Members of the Safety Committee

	Name	Function and Division
Chairmann	: F.A.R. WEBB	Site Engineer, Site and Buildings (SB)
Members	: F. BONAUDI	Engineer, Proton Synchrotron (PS)
	A.W. MERRISON	Physicist, Synchro-cyclotron (SC)
	G. MacLEOD	Physicist, Scientific and Tech. Serv. (STS)
	G. ULLMANN	Assistant Personnel Officer (ADM)
	G. LESKENS	Safety Engineer (SB)
Secretary	: J. BOUVIER (Miss)	Secretary (SB)

Other Peoples' Atoms

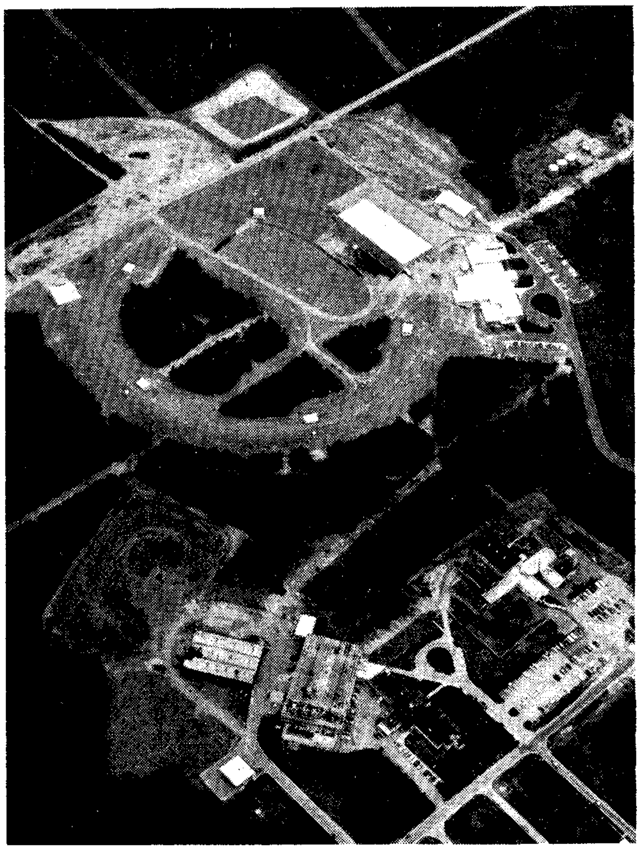
BROOKHAVEN
National Laboratory

The Brookhaven National Laboratory is located at Upton, Long Island, 110 kilometre east of New York City.

The Laboratory is a national research centre for fundamental and applied research in the nuclear sciences and related subjects, and is an integral part of the U.S. Atomic Energy Commission's nationwide programme. Its major objectives are :

— To seek new knowledge in the nuclear and other related sciences ;

— To encourage appropriate use of its facilities by qualified scientists of university and other laboratories, and industrial research groups ;



(Brookhaven Photo)
Aerial view of AGS site at Brookhaven. On this picture the ring tunnel is already covered by earthfill. Injection of particles will be done counterclockwise from the white building, left of the ring. White cube on the right is the experimental hall. Further experimental space may be provided later on area between building and pool at top centre of the picture. Below are the 3 GeV Cosmotron facilities.

Compared datas on CERN PS and Brookhaven AGS

	CERN PS	BROOK-HAVEN AGS
Construction started	1956	1956
Completion date	course of 1960	end of 1960
Accelerated particles	protons	protons
Expected energy	25 GeV	30 GeV
Pulse rate	12 to 20 p. min.	20 per minute
INJECTOR	50 MeV linac	50 MeV linac
MAGNET		
Focusing type	alternating gradient	alternating gradient
Mean diameter	200 m.	257 m.
Magnet units	100	240
Injection field	147 gauss	121 gauss
Maximum field	12-14 000 gauss	13 000 gauss
Aperture (width×height)	14×7 cm	15×7 cm
Max. power input	27 000 kW	33 000 kW
Storage system	flywheel	flywheel
Rise time	1 second	1 second
Weight of iron	3200 ton	4000 ton
Weight of coils	130 ton alumin.	400 ton, copper
ACCELERATION SYSTEM		
frequency	2.9 to 9.55 MHz	1.4 to 4.5 MHz
number of accelerating cavities	16	12 double
energy gain/turn	54 keV	80 keV
radiofrequency input	16 x 6 kW	500 kW
VACUUM SYSTEM		
Section of chamber	7 x 14.5 cm	7.5 x 16.5 cm
Length of chamber	628 m	754 m
number of pumps	66+7 in inflec-tor	48+20 in linac
operation pressure	10^{-5} mm Hg	10^{-6} mm Hg

— To assist the Atomic Energy Commission in the solution of specific problems ;

— To aid in the training of scientists and engineers in nuclear science and technology.

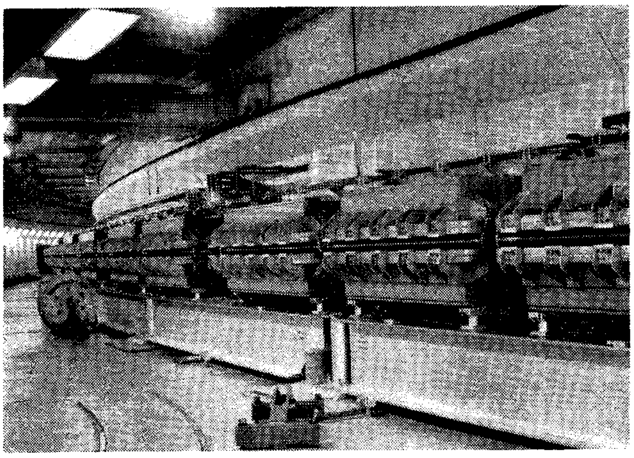
Like CERN, the Brookhaven Laboratory was established as a cooperative postwar venture in recognition of the necessity for large and expensive equipments and concentrations of scientific manpower for the successful prosecution of nuclear research. Like the other national laboratories of the U.S. Atomic Energy Commission, Brookhaven is operated under contract by a private institution, in this case Associated Universities Inc. This nonprofit educational corporation serves as an agency through which universities and other institutions can cooperate with one another and with the Government to further research and education. The governing body of the corporation is a Board of Trustees made up of one scientist and one administrative officer from each of nine sponsoring universities : Columbia, Cornell, Harvard, Johns Hopkins, Massachusetts Institute of Technology, Princeton, University of Pennsylvania, University of Rochester and Yale.

Like CERN again, the scientific programme at Brookhaven is intended primarily to employ the facilities of the Laboratory and the skills of its staff in the pursuit of scientific information, leaving largely to others the specific application of the knowledge.

A major part of the work lies in the realm of fundamental research, which seeks primarily the discovery of new facts of nature and which has always been the ultimate source of most important new applications of scientific knowledge.

Cooperation in the scientific work is also carried out through participation in the Brookhaven programme by visiting scientists on leave from other institutions or pursuing research towards a graduate degree, through collaborative projects with other institutions and through the use of the major facilities by others for research not directly connected with the Laboratory programmes. But here ends the similarity with CERN. In accordance with the Commission's over-all programme, Brookhaven studies the effects of radiation upon matter, plants and animals. It produces, uses and even sells radioisotopes. The Laboratory is finally engaged in nuclear technology and operates a new research hospital with its own nuclear reactor.

The Brookhaven Laboratory employs more than 1800 persons, of whom 350 are scientists and 650 technical personnel. In addition, there are some 200 other U.S. and foreign scientists and graduate students from universities, colleges, research institutions or industry, working at the Laboratory for short periods.



(Brookhaven Photo)
The inside of the Alternating Gradient Synchrotron tunnel at Brookhaven. Some of the 240 magnet sections can be seen on their supporting pedestals. In the magnet gaps are sections of the vacuum chamber within which the protons will be accelerated.

The AGS, Brookhaven's proton synchrotron

Fundamental nuclear research facilities at Brookhaven include a 4 MeV electrostatic accelerator, a 60-inch 20 MeV cyclotron and the « Cosmotron » which is a 3 GeV proton synchrotron.

In the field of basic research the most spectacular tool at Brookhaven is however the « Alternating Gradient Synchrotron » now in construction and expected to be completed in 1960. This is a huge accelerator similar in principle and size to the one at CERN. The AGS will have a circumference of 754 metre and be located in a tunnel, like the CERN proton synchrotron. Dr. G. K. Green, chairman of the Accelerator Development Department, is in charge of the project.

Protons produced in a 750 keV preaccelerator will be injected in the AGS by means of a 50 MeV linear accelerator. They will then be accelerated up to an expected 30 GeV energy, in the circular accelerator.

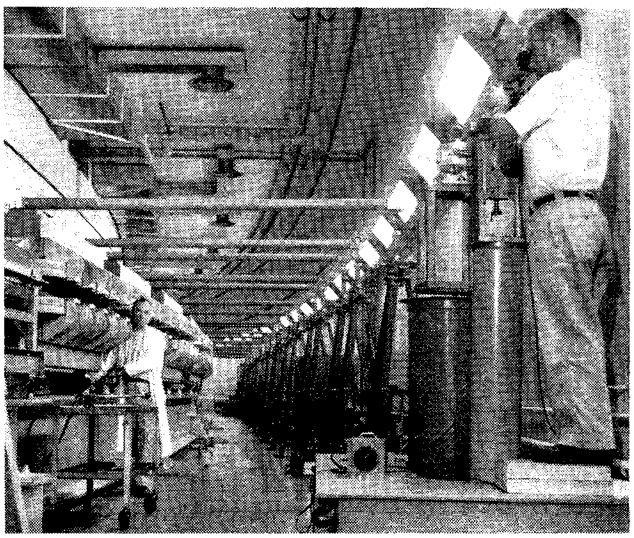
The vacuum chamber is 7.5 x 16.5 cm in cross section and the vacuum expected, 10^{-6} mm of mercury, will be obtained by 48 pumps in the ring plus 20 on the linear accelerator.

The alternating-gradient magnet has a mean diameter of 257 metre and comprises 240 magnet sections. Each magnet, roughly C-shaped in cross-section, is about 2.3 metre long and is made up of some 2800 laminations with 25 mm end plates. The total weight of steel in the magnet will be 3500 ton. Magnets will be positioned to a thousanthds of an inch with reference to 24 survey monuments driven into the earth around the ring.

Three full-sized cores of the magnet were ordered and separately tested before placing the whole order for the final 246 units, including 6 spares. Each unit has 4 exciting copper coils, 14 of which were tested before ordering the definitive lot. After these tests, all 246 cores and all the magnet coils were given extensive mechanical and magnetic trials before being placed on their foundation girders in the ring tunnel. The tests, similar to those conducted at CERN, necessitated about a year of work.

The main magnet power supply will provide 4600-volt, 6526-ampere direct current full load.
There will be 12 double acceleration cavities imparting to the particles an 80 keV energy per turn. The acceleration rate will be 20 per minute, with provision for accelerations to lower energies, of about 60 per minute.

Design studies of the AGS were begun in 1952, engineering designs in 1954. Actual construction work, i.e. trench digging, started in January 1956. All magnets were installed by June of this year and their testing under power started in July. The 50 MeV linear accelerator was expected to be assembled by the end of October. The radio-frequency and vacuum systems will probably be completed in preliminary installations at the end of this year. Finally, it is expected that "particle beams of somewhat uncertain quality will be available during the summer of 1960 and that operation... will be obtained at the end of the same year".



(Brookhaven Photo)
A view of the AGS tunnel during preliminary radial positioning of the magnets. The 24 survey monuments, one of which is seen on the right, were installed by the U.S. Coast and Geodesic Survey.

Two Commemorative Plaques

On 1 December, a commemorative plaque recalling the Swiss Confederation's financial aid towards the completion of the CERN Council Chamber and canteen, was unveiled in the hall of the CERN Administration Building.

The plaque is affixed to one of the pillars in the hall and bears the following inscription : "La Confédération Suisse a généreusement contribué par don spécial à la construction et à l'aménagement de ce bâtiment."(*)

This ceremony took place in the evening, after the meetings of the Finance Committee and of the Committee of Council. The inaugural ceremony was held in the presence of some distinguished Swiss officials and of delegates to the CERN Council attending the session on the following day.

Another bronze plaque will be shortly placed on one of the walls of the SC, bearing the text which was recorded on the parchment encased in the foundation stone at the ceremony held on 10 June 1955. This plaque will recall that :

"On this tenth day of June one thousand nine hundred and fifty five, on ground generously given by the Republic and Canton of Geneva, was laid the foundation stone of the headquarters and laboratories of the European Organization for Nuclear Research, the first European institution devoted to co-operative research for the advancement of pure science."

* "The Swiss Confederation generously contributed by a special gift to the construction of this building and its installations."

CONFERENCE PROCEEDINGS

The proceedings of the International Conference on High Energy Accelerators and their Instrumentation, held at CERN in September, will be published in December. They will be issued in one large volume of over 600 pages bound in cloth and illustrated by numerous figures.

The proceedings are in English. Following the programme of the Conference, there are chapters dealing with the need for new particle accelerators, the progress made with high energy accelerators, limitations to the construction of accelerators, the production, transport and separation of high energy particles, bubble chambers, the analysis of particle tracks, counters and other high energy particle detectors. This book will be available to persons who are not CERN staff members from the :

Scientific Information Service,
CERN, Geneva 23.

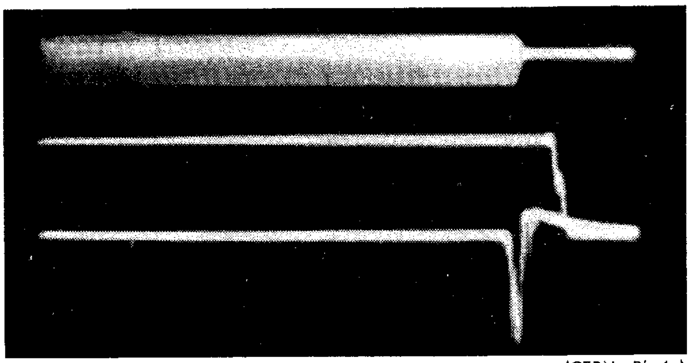
The price of the volume is Sw. frs. 50.—, including postage.

The "CERN COURIER" Referendum

(continued from page 2)

The few bloomers which creep into the periodical very rightly arouse the ire of 3 attentive readers. Some readers would like more photos and diagrams, others would like a stiffer cover and better quality paper, and yet others would like double the number of pages... all of which are interesting suggestions which we would be glad to adopt if the CERN COURIER was not limited by budget considerations, in spite of the contribution from our advertisers.

Finally, out of the 436 answers received, 7 people say they no longer wish to receive our periodical... but 5 of them omit to give their names.



(CERN Photo)

Six year's work led up to this photograph : that of the oscilloscope traces when the first acceleration up to 24 GeV was carried out, with the CERN proton synchrotron on 24 November. The top trace shows the beam intensity, which remained constant from injection (on the left) up to maximum energy. The bulge visible on the left represents the passage through the transition energy, viz about 4.7 GeV. The passage through this energy can be seen at the same level on the bottom trace, which shows the signals of a detector of lost particles. To the right of this trace the beam can be seen disappearing after acceleration. The centre trace represents the rise time of the magnetic field.

On July 27th the 100 units forming the magnet of the proton synchrotron were energized for the first time.

These electrical tests marked the beginning of a general series of tests of all vital parts of the big accelerator. The performance of the linear accelerator, the inflector, the pole face windings and the accelerating cavities, were to be studied in detail over many weeks.

On September 16th, while the International Conference on Accelerators was being held at CERN, a highly important announcement was made : a proton beam injected into the machine had made a complete turn for the first time. This meant that the linear accelerator, which gives the particles their initial acceleration, was working normally. It also meant that the magnets were not only receiving the electric pulses perfectly but also that they were aligned with the precision necessary for keeping the beam on its circular orbit.

On 13 October, after the radio frequency accelerating system had come into operation, events moved fast.

On the 15th, an accelerated beam was observed during a few millisecond. On October 22 the energy reached 400 MeV or eight times the injection energy.

On October 27th "phase locked" acceleration was tested for the first time. Even without the radial beam position control operating the energy went up to 1.5 GeV and sometimes higher.

Then, after the operations outlined in the article "Last month at CERN", came Friday 13 November. That evening, radial control of the beam position was tested for the first time. But the method adopted was not effective enough and the Radio frequency Group decided to change over to another control system.

On the evening of 24 November, this new system was tried out. The proton beam at once reached 4.7 GeV, namely the "transition energy", at which level the pessimists had predicted beam losses. At 7.22 p.m. the phase-changer necessary for accelerating beyond

Last month at CERN

(continued from page 1)

energy was believed to have reached 4 GeV. One was then on the verge of reaching **maximum energy.**

The **Hydrogen Chamber** Experimental Group was the last to carry out an important experiment on the synchro-cyclotron before down. A somewhat compl rangement was used to tra transform the beam be accelerator and the bubble Four focusing lenses, besid at the output end of the cyclotron, and three sepa bending magnets had to between the accelerator chamber, which is surrou by its own magnet. The 30 gen bubble chamber was used during twelve cons hour periods. The results elastic collision of 350 an

SUCCESS IN FOUR MONTHS

the transistion energy was switched on. Without visible loss of intensity the proton beam went up to approximately 6 GeV, the maximum energy possible with the magnet programme so far used.

Then the magnet programme was changed to reach a top field of 12 500 gauss in the hope of obtaining higher energies. It was 7.40 p.m. on 24 November when the beam was accelerated to approximately 24 GeV, twenty-four thousand million electronvolt, i.e. the maximum energy under normal operating conditions. The acceleration was steady ; moreover, 90 % of the proton beam trapped by the synchrotron reached maximum energy. According to the physicists, this proportion is surprisingly high.

On the morning of 25 November all the members of the Proton Synchrotron Division gathered in the Main Auditorium. John B. Adams, under whose leadership CERN's gigantic project has been successfully carried out, gave an account of the operations of the last few days. Expressing his gratitude to all those who, at CERN, had played a part in constructing and bringing the accelerator into operation, he announced : "Nuclear physicists will soon be able to use the machine".

Next, Professor C. J. Bakker, Director-General of CERN, said : "Of course such a machine could only be the result of team work. But the team could not have worked at full pitch without the impetus of a leader : this leadership was provided by J. B. Adams. It is with the greatest of pleasure that I convey to him and his Division the warmest congratulations of the President of the Council."

"CERN", added Professor Bakker, "is now operating on two fronts. One is fundamental scientific research, where we are helping to unravel the laws governing matter, and the other is the application of natural laws in an original way : the proton synchrotron is a magnificent example of the second kind. At present, the proton synchrotron has to be finally adjusted before it becomes available to the research workers."

In conclusion Professor Bakker added that even though science is international and all discoveries and achievements must form part of a common pool, Europe can nevertheless be proud to hold once more a leading position in a scientific field.

The meeting closed on a note which was typical of the friendly spirit existing between scientists all over the world. Holding up a bottle of vodka, J. B. Adams read from the label : "To be used after reaching a kinetic energy of more than 10.1 GeV". This bottle had been given to him at the Conference in September by Russian physicists working with the 10 GeV synchro-phasotron, which up to 24 November was the world's most powerful accelerator. "The bottle is now empty" said John Adams. "Inside it I am going to slip this photo of the oscilloscope traces at the moment when 24 GeV were reached. Then we shall send it back to Moscow."

After this, J. B. Adams calmly relit his pipe.

THE PS CABLES

Laying of the cables of a machine as complex as a 25 thousand million electronvolt proton synchrotron is of course a most extensive job, and one of prime importance for the smooth operation of the machine.

The cabling system was designed by the Control Section of the Division's Electrical Engineering Group and the cables were laid and connected by outside contractors under close supervision of the Section.

The PS network of cables for the transmission of the signals and remote controls can be subdivided into two large sections : the synchrotron proper and the experimental area including the counting room.

The transmission of signals and remote controls **for the proton-synchrotron** makes use of a network of cables connecting all PS components to the control centres of the machine and these centres between themselves.

For this section the total length of multicore cables used is 221 000 metre. As there is an average number of 15 cores per cable the overall length of wire reaches the astronomical figure of 3 315 000 metre... to which an approximate 28 000 metre of internal wiring may still be added.

To connect, clamp or terminate the various lengths of wire making up this impressive amount, 146 junction boxes, 66 000 double terminals and 3000 banana sockets have been installed.

In addition there is also an important coaxial cable installation. All coaxial cables are of the 75 ohm variety. There are 150 kilometre of them of the « flexible type » and some 6600 metre embodying a helical membrane around the inner coaxial core.

The transmission of signals and remote controls **for the experimental area** also requires an elaborate cabling network. Ninety-three kilometre of coaxial cable will connect 18 terminal boxes scattered in the floor of the experimental area, to the large counting room overlooking the South Experimental Hall. There, all results of experiments taking place in the halls will be concentrated. All in all, no less than 2500 sockets are or will be mounted in the junction boxes and in the terminal boxes in the floor.

H. Bakker (centre) and J. Thorlund belong to the proton synchrotron Control section which is responsible for the cable layout. Here they discuss the laying of cables with a workman from an outside firm.

(CERN photo)

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The CERN **synchro-cyclotron** stopped working on the morning of 23 November in order that the modifications mentioned in our last issue might be carried out. A few days before, an important improvement had been made in the starting system of the accelerator. In the past the synchro-cyclotron — like many other accelerators — could only be started after "warming up" for about 15 minutes, on account of the performance of some of the capacitors in the radio frequency accelerating system. The Technical Development Group remedied this state of affairs and in future it will be possible to start the machine up immediately. This will facilitate consecutive experiments. A decision and scientific importance was taken : CERN agreed to receive as a gift the private library of the late **Wolfgang Pauli**, a Nobel prizewinner.

Near the Main Workshop, on the grass in front of the synchro-cyclotron, a **store** is being erected for chemicals and inflammable products, to serve not only the Main Workshop but also the Synchro-cyclotron and Scientific and Technical Services Divisions. The barracks previously occupied by the contractors' staff have been adapted to accomodate scientists of the Accelerator Research Group. The West end of the big PS Experimental Hall is at present being prepared for testing bubble chambers when the particle beam is extracted from the PS ring.

The Fourteenth Session of the CERN **COUNCIL** was held on the 2nd of December. A report on this subject will appear in the next issue. **- Ed. -**

FUNDAMENTAL NUCLEAR RESEARCH

The question most often asked by newly-arrived non-scientific staff members or visitors and even by a surprising number of technically-minded people is "What is CERN doing?".

The answer is quite simple : "Fundamental Nuclear Research". But this requires in itself an explanations. These will be found in several articles to appear in "CERN COURIER". After their presentation in this periodical, it is expected to reprint them in a separate booklet available for general distribution.

The coming series will comprise the following chapters, the first of which appears in this issue :

— *"The purpose of fundamental nuclear research";*
— *"How it began and grew";*
— *"The tools of the nuclear physicists".*

THE PURPOSE OF FUNDAMENTAL NUCLEAR RESEARCH

Fundamental nuclear research is the contemporary phase of Man's long quest to explain the structure of matter.

This investigation has been going on since times immemorial. It began in all probability with Man's ability to ponder on his surrounding world. Indeed the question as to whether matter is infinitely divisible or composed of discrete particles, occurs naturally to thinking persons some time in their life. The last decades, however, witnessed an extraordinary upsurge of interest and results in this field. Indeed, it is only since the beginning of this century that Man has been building tools to explore the world within the atom and achieve a better understanding of the atomic nucleus.

One misconception about CERN is that it deals with atomic power. CERN has nothing to do with power generation. In point of fact, our laboratories are huge consumers of electric power : in 1960 when both CERN accelerators will be in operation, electric power consumption may reach 40 million kWh.

Elementary particles physics is the science in which CERN is engaged. It is a science independent of direct practical applications, be they peaceful or military. On the contrary it only pursues discovery for its own sake.

Some twenty years ago no direct applications could be foreseen for nuclear physics either. Now the application of nuclear physics has led to two fields full of economic—and alas also military—implications : nuclear chemistry and nuclear engineering.

But whatever may be the position of elementary particle physics 20 years hence, it now pushes further and further the border between the known and the unknown in physics.

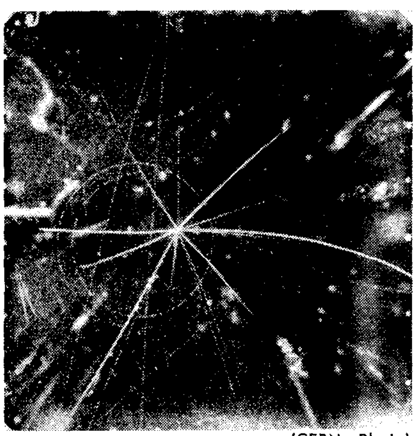
The understanding of the submicroscopic universe inside matter has proceeded down finer and finer steps. It has been—and still is—like peeling an onion, layer after layer. Progressively, scientists distinguish the basic components : the fundamental or elementary particles.

Elementary particles

This term, "elementary particles", has had quite a few meanings along the centuries. Let us first recall the **four basic elements** of the Greeks : water, earth, air and fire. Much later, the **different kinds of matter** such as iron, oxygen, salt, carbon, quartz etc. were called "elementary". A finer structure of matter, the **atom** making up the molecules, was put forward mainly in the last century. There were then some 100 different kinds of atoms. These were regarded as the "elementary particles".

When, early in this century, scientists first glanced inside the atom, they were able to explain it as a tiny core—the nucleus—surrounded by a number of **electrons** whose configuration determined the chemical properties of the different atoms.

Then some 40 years ago, the submicroscopic nucleus was broken. The rather crude observation at that time nevertheless showed all nuclei as combinations of **protons** and **neutrons.** And thus a new explanation could be given to the "elementary particles". They were not any more the 100-odd atoms : nature seemed to be more simple than it was believed, and all matter, that is the hundred-odd chemical elements, was made of protons and neutrons in the core of atoms and of electrons revolving around them.



(CERN Photo)
An example of what happens when a fast charged particle hits a nucleus. In this cloud chamber photograph taken in 1956 by CERN physicists atop the Jungfraujoch, an energetic particle coming from above causes the disintegration of a nucleus of argon. From such experiments scientists are able to analyse the properties of particles.

But something was still added to the tiny three: the **photon.** Physicists recognized that particles had wave properties, while light could also be identified as having particle character. And so elementary physics resolved to four fundamental grains. Not for long however could nature be considered so simple. Theory and experimentation were soon to complicate the whole picture again.

Today elementary particles number **thirty-two,** whose combinations and interactions seem to be the basis of all matter structure. Scientists at CERN, at Brookhaven, at Dubna and in many universities and laboratories the world over, are elaborating on their structure and their interactions.

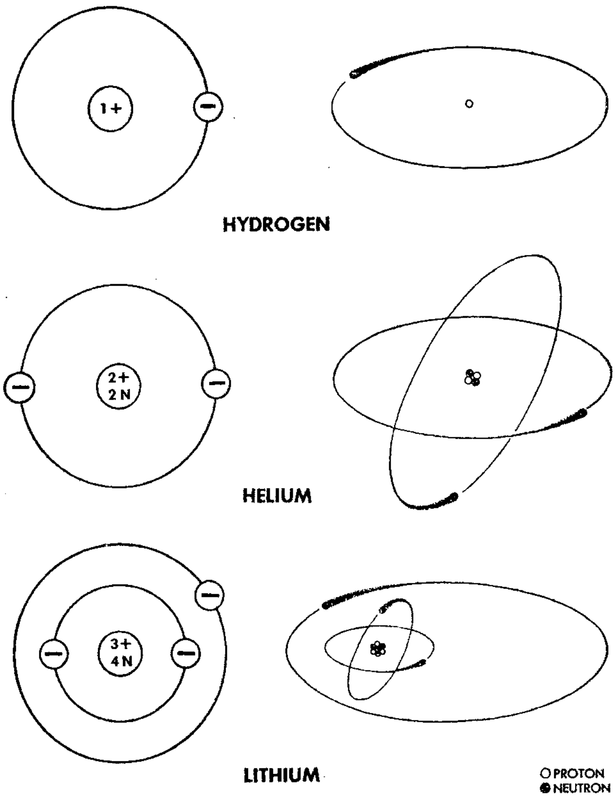
Of their findings depends the complication or the simplification of the elementary particles general picture. Already some masses, electric charges and interrelationships are known, while it has been ascertained that some have a " spin ", i.e. that very loosely speaking they revolve on themselves.

Furthermore another baffling phenomena has been established. About half of the elementary particles are "antimatter". This means that all charged and neutral particles have twins with some properties identical, some opposite. Thus, electric charges may be opposite while masses and spins are identical and interaction with other elementary particles closely related. The only exception to this phenomena are the photon and the neutral pi-meson where particle and antiparticle are the same.

The classification of fundamental particles

At the present stage of knowledge, the classification of the fundamental grains of matter lists five groups separated according to the main characteristics of the particles : mass, electric charge and spin.

● The PHOTON is the only member of the first group. The photon, is the quantum—the unit—of electromagnetic radiation, i.e. light, the X-rays and the gamma rays.



Right are models of atoms. At the centre of each drawing is the nucleus, an aggregate of neutrons and protons where the weight of the atom is almost entirely concentrated.
Fundamental nuclear research such as conducted at CERN deals only with the knowledge of what goes on inside the nucleus.
Electrons are represented around the nucleus on arbitrary orbits. This picture of the atom should however not be taken literally. The size of the nucleus bears the same proportions to the atom as a golf ball to a circle 7 kilometre in diameter.
The left column of the drawing is a simple way to represent the atom structure of the three simplest elements : hydrogen, helium and lithium. The picture would of course be more complicated for heavier and more elaborate elements such as iron, lead, uranium, etc. In the drawing, the mark + means proton, a - stands for electron and N for neutron.
(Westinghouse drawing)

● The LEPTON group comprises the neutrino, the electron and the mu meson or muon.

The neutrino has neither mass nor charge, just like photons. Unlike these however, it has a different spin and its interactions with other particles are extremely weak. This is why it can be said as an example, that at night our bodies are traversed by billions and billions of neutrinos which have already passed through the earth from the sun shining behind it.

The **electrons** which were the first known particles, surround the nuclei to make up the atoms. The mass of the electron has been chosen as the unit to measure the masses of other particles. Its electric charge is negative, while its antimatter counterpart, the positron, is positively charged.

The **mu meson** or **muon** is 206 times as heavy as the electron and behaves like it. The mu meson is however unstable, it decays after about two millionth of a second into an electron, a neutrino and an antineutrino. It will be noted that despite its name, the muon is placed here rather than in the following group.

● the MESON group comprises the pi and k mesons. There are three kinds of pi mesons or **pions :** neutral, positively charged and negatively charged. With about 270 electron-mass, all pions are slightly heavier than muons. Their part is vital in the structure of matter : acting as main constituent of the nuclear glue, they bind protons and neutrons together into the nuclei. Freed, the pions decay into other particles. Charged pions decay into muons and neutrinos, the muons decaying themselves as described above. A neutral pion gives two photons in less than 10^{-15} second, that is one billionth of a millionth of a second... Desintegration of the charged pion directly into an electron—that is without first going through the muon stage—was first observed, in 1958 by a team of CERN's synchro-cyclotron physicists.

The **k mesons,** with the hyperons in the fifth group, are the youngest of the family and are referred to as "strange particles". There are neutral and positively charged k mesons as well as their antiparticles, respectively neutral and negatively charged. All have a mass of about 970 times that of the electron. They decay in many different ways, the observation of which brought an important discovery : that parity is not always conserved.

● The NUCLEON is made up of **protons** and **neutrons** which, as said above, are components of all nuclei. Their mass is about 1836 times that of the electrons. Like the electron, the proton, the neutron and their antiparticles are stable, although it should be said the neutron is stable inside the nucleus only. A free neutron decays with a half-life of 12.5 minutes into a proton, an electron and an antineutrino.

● The HYPERONS are the most recently discovered. Under this heading are gathered the **lambda, sigma** and **xi** particles. These are still mostly mysterious and "strange" particles, much heavier than all others : their masses range from 2182 to 2585 times that of the electron. Only the giant accelerators—those in the GeVs range—can produce them artificially. This is why hyperons are still mostly unknown. Newly-built large accelerators like CERN's 25 GeV proton synchrotron will unquestionably provide priceless tools to study those particles.

The building blocks of nature

This is how the general picture of the fundamental building blocks of nature appears at this time.

The self-imposed task of modern physicists is to probe still further into the structure of matter. They hope to know exactly how many different particles make up all matter. They hope to understand what are their mutual interactions. They hope to achieve a complete theory of the powerful forces that bind elementary particles together. They hope to draw a picture of the structure of particles themselves.

They hope... for the hope of knowledge is the ever driving incentive that urged discoverers forward since the dawn of humanity. In the case of fundamental nuclear research, it may take years to get a clear, coherent picture of all subatomic phenomena, years interspersed with contradiction and disappointment.

One thing is certain in any case : the large accelerators now going up in America, in Europe and in Russia will, with their associated instrumentation, greatly help to reach this goal..

IN A COMING ISSUE

Part II : " How fundamental nuclear research began and grew. "
This article will include a new chart of elementary particles.